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FISCAL POLICY AND ECONOMIC DEVELOPMENT

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This paper offers possible explanations for three generally observed facts about fiscal policy and development: (F1) the relative size of government increases as an economy develops, (F2) the rise in government and taxation are associated with rising or constant economic growth rates, and (F3) today's developing countries have larger government sectors than today's developed countries had at similar stages of development. The explanations for these facts are based on the structural transformation from traditional to modern production, rising public infrastructure investment, and less democratic governments in many of today's developing economies.

Keywords: Fiscal Policy, Structural Transformation, Wagner's Law

1. INTRODUCTION

There are several interesting empirical connections between economic development and fiscal policy. First, the relative size of government trends upward as an economy develops—a phenomenon that is known as Wagner's Law. This feature is exhibited in Figure 1, which gives the historical ratio of government purchases to GDP, averaged over 11 currently developed countries.

Second, economic growth rates have typically risen, or at least remained constant, in the face of strong upward trends in taxation and government expenditures. Figure 2 presents the growth rates in productivity per worker for the 11 countries in Figure 1. The rising growth rates seem to contradict the widespread notion that taxation is detrimental to growth [see, for example, Stokey and Rebelo (1995) and Lindert (2004)].

Finally, the relative size of government differs significantly across countries at similar levels of development. In particular, current low-income countries have higher tax rates and larger governments than current high-income countries did at a similar stage in their economic development. Table 1 confirms that tax rates and government purchase shares in today's developing countries are not much below

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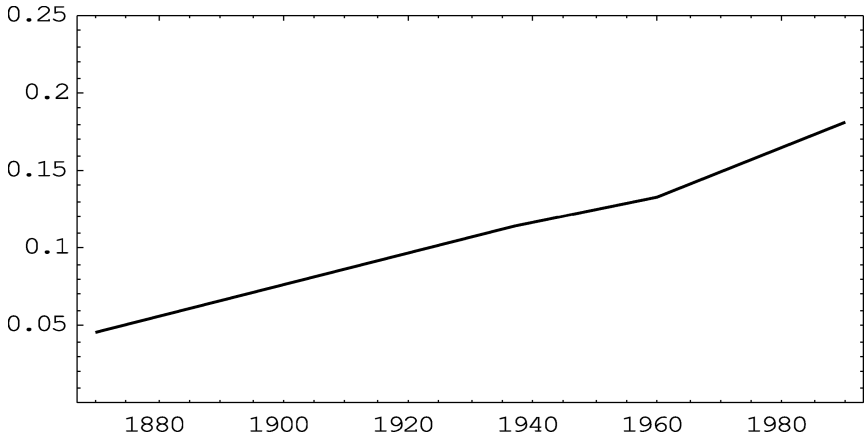


FIGURE 1. Government purchases (share of GDP). The plot is the average government purchase share for 11 currently developed countries (Australia, Canada, France, Germany, Japan, the Netherlands, Norway, Spain, Sweden, the United Kingdom, and the United States). *Source*: Tanzi and Schuknecht (2000, Table II.1).

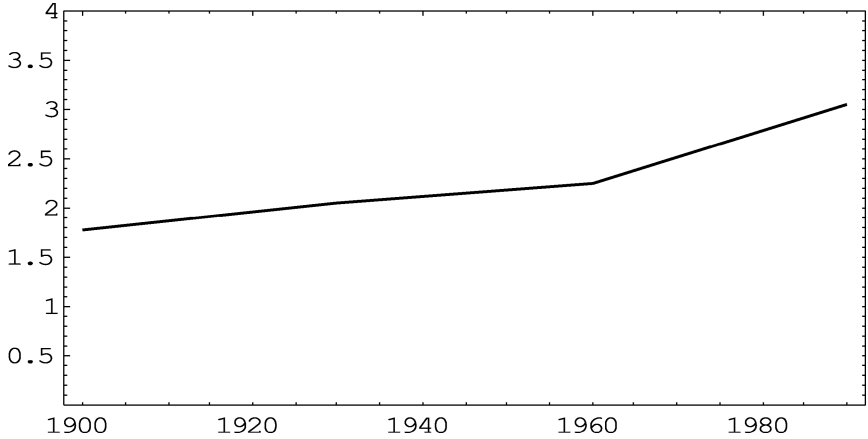


FIGURE 2. Rate of growth in productivity per hour worked (annualized percent). Growth rate is the annualized value over the previous 30 years. From 1870 to 1960, for 6 developed countries (France, Germany, Japan, the Netherlands, the United Kingdom, and the United States), and from 1960 to 1990, for all 11 countries in Figure 1. *Sources*: Maddison (1987, Table A-5) and van Ark (1996, Table 1).

those of *today's* developed countries and are well above the purchase shares of today's developed countries in 1870.

We present a single model of development that offers possible explanations for all three observations. The model contains two sectors of private production. There are a modern sector, where technologies based on physical capital are used, and a traditional sector, which uses land-intensive technologies. The exogenous force

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TABLE 1. Government in developed and developing countries

	Government purchases (% of GDP)	Capital income tax rate (maximum statutory rate)	Personal income tax rate (maximum statutory rate)
Developed countries (1990s)	18.9	29.6	42.8
Developing countries (1990s)	14.2	26.7	34.7
Developing countries (1870)	4.6	N.a.	N.a

Sources: Government purchase share for 1990 from Jha (2007, Table 9). Government purchase share for 1870 from Tanzi and Schuknecht (2000, Table II.1). Tax rates for 1996–2001 from Gordon and Li (2005).

for economic development is technical progress that is biased toward the modern sector. As a consequence, the economy experiences a structural transformation as it develops—the traditional sector shrinks and the modern grows. There are three types of economic agents in the model. First, working households supply labor to each sector. Second, landowners hire labor and operate the traditional technology to produce goods. Finally, a government sets fiscal policy to maximize its own welfare and the welfare of the two types of private sector households.

We focus on the early stages of growth, when government spending is dominated by purchases of both consumption and investment goods. We ignore the growth of government transfers and the welfare state that have kept the relative size of government growing in the later stages of development.[1] In the model, the government chooses an income tax rate and decides how much of the tax revenue to consume itself, how many consumption services to provide to the private sector, and how much to invest in public infrastructure.

The two private sectors of the economy are affected differently by the government. The traditional sector is harder to tax. Typically, large fractions of the labor employed in the traditional sector receive wages via in-kind payments and much of the traditional sector's output is consumed without being traded and recorded on a regular basis.[2] The traditional sector also benefits less from government purchases because traditional production relies less on public infrastructure, and because traditional producers typically reside in rural areas where government consumption services are harder to deliver.

We argue that rising tax rates are a consequence of the structural transformation from traditional agriculture to industry. Raising tax rates is costly to the government because higher tax rates reduce the tax base by encouraging workers to remain in the traditional sector. We show that the size of this negative tax base effect is proportional to the size of the traditional sector. Thus, at early stages of development, when the traditional sector is large, increasing the tax rate is more costly because it causes larger reductions in the tax base. As the exogenous force of technological change reduces the size of the traditional sector, the marginal cost of taxing falls, and tax rates begin to rise. The economic transformation *causes* the tax base and the tax rate to rise over time.

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The rising share of the public sector does not lead to lower economic growth because part of the tax revenue is used for public infrastructure investment. A rise in public infrastructure investment will increase economic growth. Empirical evidence suggests that public investment is subject to diminishing returns, similarly to investment in private physical capital. Other things constant, diminishing returns imply that growth rates fall over the course of development. However, the diminishing returns of a given unit of public investment can be offset by a rise in the amount of investment. If sufficiently greater investment takes place each period, then growth rates need not fall despite diminishing returns. The combination of a rising tax rate and a rising tax base allows this possibility. Our calibrations show that for a typical history of the economic transformation and the associated rise in tax rates, economic growth rates can rise or remain roughly constant for extended periods of time.

This is not to say that taxation is necessarily good for the growth of today's developing countries. We explain the relatively high tax rates of currently developing countries by the absence of institutions that give weight to working households in the private sector. Obviously, in countries where the ruling elite places a relatively low weight on the welfare of the private sector, tax rates will be relatively high. The model also predicts that tax rates will be high in countries where landowners in the traditional sector are favored by the government. This is because high tax rates encourage workers to stay in the traditional sector, which lowers wages there and increases the profits of traditional producers. In either case, high tax rates limit the pace of the structural transformation from traditional to modern production. As a result, economic growth will be slower than in economies where tax rates are not as high. The model predicts that countries with less democratic governments or governments that favor wealthy landowners will experience high tax rates and slow growth.

We also show that allowing governments to borrow to finance public investment leads to higher tax rates than would otherwise be the case. However, the ability to borrow is unlikely to explain the relatively high tax rates of today's developing countries. During their early stages of development, many of the Western Offshoot countries borrowed more heavily than today's developing countries.

2. RELATED LITERATURE

Our paper is related to several works in the literature, including those that focus on the growth of government, taxation and the traditional sector, and the connection between land inequality and development.

2.1. Growth of Government

Most of the literature on the size of government focuses on the sharp rise in social spending that occurred in developed economies after World War II. Lindert (2004) argues that the rise was the consequence of a transition to fuller democracy with

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more widespread political voice. In contrast, our explanation for the growth of government is a purely technical one that precedes and complements the effects of growing political participation—the structural transformation moved economic activity into more formal modes of production that are easier to tax.

Explaining why the growth of government and taxation does not slow economic growth is easier for us than for those who focus on social spending, because in our model, at least some of the rise in taxes is spent on productive public infrastructure. Lindert argues that some types of social spending are also productive (e.g., spending that supports continuity in the professional careers of women or that increases the health of children and working-aged adults). He discusses two additional reasons that the growth of government does not slow economic growth, which we do not include. First, as the government becomes larger, policymakers take more care to tax in ways that minimize distortions (e.g., the taxation of capital and marginal income tax rates have both declined over time). Second, some policies have reduced employment (welfare, unemployment compensation, and public pensions) and in doing so have removed workers with below-average productivity from the workforce, resulting in higher labor productivity.

2.2. Taxation and the Traditional Sector

Several studies have found a strong negative correlation between the relative size of the agricultural sector and the relative size of government, other things constant [Peltzman (1980), Burgess and Stern (1993), Tanzi (1991), and Stotsky and WoldeMarian (1997)]. In fact, the studies find that the relative size of the agricultural sector is more closely correlated with the relative size of government than are other indicators of development, such as income per capita. These empirical studies provide motivation for the development of our structural model.

There is related literature in which the concern is that taxation and other government policies push economic activity underground [see the reviews by Schneider and Enste (2000, 2002) and Schneider (2007)]. In this literature, the paper closest to ours is Loayza (1996). He looks at how government policies contribute to the informal sector and how the informal sector affects long-run economic growth in an endogenous growth model. His theoretical and econometric analysis indicates that the informal sector reduces both public infrastructure investment and economic growth—as in our analysis.

However, while Loayza focuses on the urban informal sector and long-run balanced growth, we focus on the rural informal, or traditional, sector and the structural transformation. To do this, we build a framework that allows *transitional* growth, where the size of the traditional sector, economic growth rates, and tax rates all change over time. Our interest is in the interaction between transitional growth and the setting of tax rates when the traditional sector is difficult for the government to tax. We find that the reduction in the tax base, when tax rates are raised, is directly proportional to the relative size of the traditional sector. In this sense, tax evasion is more of a problem for developing economies—even

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on the margin. When the traditional sector is relatively attractive in general, it gives households a "legal" way to avoid taxes. When the traditional sector is not generally attractive, households and firms will remain in the modern sector and must illegally avoid taxes or create more complicated legal ways of avoiding taxes.

2.3. Land Inequality and Development

There is a growing literature suggesting that land inequality may hamper growth. The survey by Erickson and Vollrath (2004) mentions general mechanisms for the negative effects of land inequality that work through institutions, influence over agricultural policy, credit market development, and support for public schooling. A common feature of the mechanisms is the attempt by politically powerful landowners to maintain a low-cost work force in agriculture by limiting the options of workers outside of agriculture [see Burgess and Stern (1993) for some specific examples from Latin America}.

We argue that an additional way that landowners might maintain a low-cost work force is to support high tax rates on labor and capital generally. If incomes are easier to identify and tax in urban manufacturing, then a high-tax-rate environment will favor the agricultural sector, especially when the production and payment methods there are informal. As workers avoid high tax rates by supplying labor to agriculture, the wage rates in agriculture will be driven down, to the benefit of landowners.

3. THE MODEL

We use an overlapping-generations model where agents live for two periods. The standard overlapping-generations setting is extended to include two private sector household types (workers and traditional producers), two sectors of production (traditional and modern), and a government that chooses fiscal policy based on its preference for its own consumption and the welfare of the two household types in the private sector. The purpose of the model is to show how economic growth, in particular the economic transformation from traditional to modern production methods, interacts with a country's fiscal policy. To simplify the exposition, and to focus attention on public capital accumulation as a source of economic growth, we assume that the economy is small and open to international flows of *private* capital.

3.1. Production

There is one good in the economy that is produced in two different sectors of production, as in Hansen and Prescott (2002). The modern sector is composed of standard neoclassical firms that hire capital and labor to maximize profit. The

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technology is a Cobb–Douglas production function,

$$Y_t = K_t^{\alpha}(D_t L_t)^{1-\alpha}, \tag{1}$$

where Y denotes output, K is the physical capital stock, DL is the effective labor supply, and α is the capital share parameter. The effective labor supply is the product of a labor-productivity index, D, and the amount of raw labor allocated to industry, L.

The neoclassical firms operate in perfectly competitive markets, and the standard profit-maximizing factor-price equations for the rental rates on human and physical capital are

$$W_t = (1-\alpha)\, D_t k_t^{\alpha} \tag{2a}$$

$$1 + r = (1-\sigma_t)\alpha k_t^{\alpha-1}, \tag{2b}$$

where $k \equiv K/DL$, r is the internationally determined after-tax return to capital, σ_t is the domestic income tax rate on the return to physical capital, and the depreciation rate on private physical capital is assumed to be 1.

The same good is produced in the traditional sector. Production in the traditional sector is based on methods that depend on land and not on physical capital. Each traditional producer owns a fixed plot of land. There is no formal market for land in the traditional sector; instead each plot of land is passed from one generation of landowners to the next generation.[3] Landowners possess a production technology given by

$$O_t = A_t f_t^{1-\alpha}, \tag{2}$$

where A is TFP in the traditional sector and f is the input of raw labor.

Traditional producers compete with modern-sector firms in the market for labor. The labor share in traditional production is assumed to be the same as in the modern sector, so that the aggregate labor share does not vary with the stage of development, as is suggested by empirical evidence [e.g., Gollin (2002)]. The demand for labor by traditional producers equates the marginal product of labor to the traditional sector wage, $\tilde{W}_t$:

$$\tilde{W}_t = (1-\alpha) A_t f_t^{-\alpha}. \tag{3}$$

The pre-tax traditional-sector wage rate will, in general, differ from the pre-tax modern sector wage because the government can tax income generated in the modern sector more easily than that in the traditional sector.

3.2. Households

There are two private sector household types—workers and landowners. Working households derive their income from supplying labor to the modern and traditional sectors during the first period of their lives. They retire in the second period. Workers choose consumption when young, C_t^y, and when old, C_{t+1}^o, to maximize utility, $\ln C_t^y + \beta \ln C_{t+1}^o + \gamma \ln C_t$, subject to a lifetime budget constraint,

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$C_t^y + C_{t+1}^o/1 + r = \omega_t$, where β and γ are positive preference parameters, ω_t is after-tax wage income, and C_t is the flow of government goods and services provided per household (e.g., police protection and public water supply).[4]

After-tax wage income is the sum of income earned from each sector; i.e., $\omega_t \equiv l_t(1-\sigma_t)W_t + (1-l_t)(1-\varepsilon\sigma_t)\tilde{W}_t$, where l is the fraction of work effort supplied to the modern sector and ε is a parameter that lies between zero and one. If the government can tax the entire wage paid to traditional workers, then $\varepsilon = 1$, and if the government cannot tax traditional wages at all, then $\varepsilon = 0$. The consumption demand functions of workers are

$$C_t^y = \frac{\omega_t}{1+\beta} \tag{5a}$$

$$C_{t+1}^o = \frac{\beta\,(1+r)\,\omega_t}{1+\beta}. \tag{5b}$$

Traditional landowners have the same preferences as workers. The same amount of government purchases per household is provided to the traditional sector as to the modern sector. However, traditional sector households are assumed to be more geographically dispersed, so that the benefit of the government services is less.[5] To capture the lower benefit of government services, we write the traditional sector utility function as $\ln \tilde{C}_t^y + \beta \ln \tilde{C}_{t+1}^o + \gamma \ln(\varepsilon^c C_t)$, where $0 < \varepsilon^c \leq 1$.

Traditional landowners derive their first period income from the after-tax residual income generated by traditional production, $(1-\varepsilon\sigma_t)(O_t - \tilde{W}_t f_t) = (1-\varepsilon\sigma_t)\frac{\alpha \tilde{W}_t f_t}{1-\alpha}$, where the equality is established by using (4). This income may be interpreted as a combination of land rents and compensation for the landowner's time.

The labor demand and consumption demand functions for traditional households are

$$f_t = \left[\frac{(1-\alpha)\,A_t}{\tilde{W}_t}\right]^{1/\alpha} \tag{6a}$$

$$\tilde{C}_t^y = \frac{1-\varepsilon\sigma_t}{1+\beta}\frac{\alpha \tilde{W}_t f_t}{1-\alpha} \tag{6b}$$

$$\tilde{C}_{t+1}^o = \frac{\beta\,(1+r)\,(1-\varepsilon\sigma_t)}{1+\beta}\frac{\alpha \tilde{W}_t f_t}{1-\alpha}. \tag{6c}$$

3.3. Equilibrium

We consider equilibria where both sectors are operating. This requires that (i) workers be indifferent about supplying labor to each sector, (ii) landowners choose to operate a traditional business rather than becoming workers themselves, and (iii) the labor market clears each period.

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To satisfy condition (i), the after-tax wage rate in the two sectors must be equal, $(1-\sigma_t)\,W_t = (1-\varepsilon\sigma_t)\,\tilde{W}_t$. This condition gives us

$$\tilde{W}_t = \left[\frac{1-\sigma_t}{1-\varepsilon\sigma_t}\right] W_t. \tag{7}$$

To satisfy condition (ii), the maximum utility of landowners, $\tilde{V}_t$, must be greater than or equal to that of workers, V_t:

$$\tilde{V}_t \geq V_t. \tag{8}$$

Finally, to satisfy condition (iii), the demand for labor in the traditional sector must equal the supply to that sector,

$$\tilde{N} f_t = N_t(1-l_t), \tag{9}$$

where N_t is the number of working households, $\tilde{N}$ is the number of landowners, and l_t is the fraction of workers in the modern sector. We assume that the numbers of land plots and landowners are constant over time, but that the population of workers grows at the exogenous rate n.

The equilibrium conditions lead us to our first proposition (proofs of the propositions are found in the Appendix).

PROPOSITION 1. *The traditional sector will operate as long as*

$$\frac{(1-l_t)}{\tilde{m}_t} \geq \frac{1-\alpha}{\alpha}\left(\frac{1}{\varepsilon^c}\right)^{\gamma},$$

where $\tilde{m}_t \equiv \tilde{N}/N_t$.

The proposition states that the traditional sector will operate as long as the ratio of workers to landowners in the traditional sector is sufficiently high. When this ratio is high, running a traditional business generates a relatively high level of residual income per landowner. The ratio can remain high, even when the fraction of labor in the traditional sector is low, provided that the absolute number of workers is high relative to land and landowners. Throughout our analysis, we assume that the ratio of workers to land is sufficiently high to prevent owners from abandoning their land.

3.4. Government

We take a "reduced-form" approach to the formation of policy. We model the government like any other economic agent—by specifying its preferences, constraints, and objectives. There is no deep model of the politics that determine how the government is chosen and how its policies are influenced by voters and interest groups. Instead we take as given the politics of a country, which determine the "reduced-form" preference parameters that dictate the government's concern

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with the welfare of the general population, of different household types, and of households that make up the government itself.

Government officials have preferences defined over their own consumption, c_t^g, and the welfare of the two private-sector household types. We assume that the current government cares about government as an on-going institution (i.e., they care about the future operations of the government and the welfare of future government officials) and the welfare of the country's future citizens. We also consider the special case where there are no distinct government officials. In this case, the optimal government policy is directed by the private households, at no cost, with possibly different political power of different household types. Even in the absence of explicit officials, we assume that the government continues to consider the policy effects on future generations.

The preferences that determine government policy are given by the intertemporal utility function, $\sum_{t=0}^{\infty} \beta^t \{\phi^g \ln C_t^g + \phi \ln V_t + \tilde{\phi} \ln \tilde{V}_t\}$, where ϕ^g, ϕ, and $\tilde{\phi}$ are constant preference parameters. We think of the government's preference parameters as functions of exogenous political institutions and the de facto political power of the private sector households. Countries with less democratic institutions and fewer constraints on the executive will tend to have governments that place less weight on the welfare of the private sector households as a whole (low values for both ϕ and $\tilde{\phi}$), or perhaps that give disproportionate influence to wealthy landowners (a high value for $\tilde{\phi}$ and a low value for ϕ). By varying the preference parameters, we can capture a government of the public interest (the "helping hand") or a government of its own private interests (the "grabbing hand")

The single-period government budget constraint is

$$C_t^g N_t^g = \sigma_t[W_t l_t + \varepsilon \tilde{W}_t(1 - l_t)]N_t + \sigma_t[(Y_t - W_t L_t) + \varepsilon(O_t - \tilde{W}_t f_t)\tilde{N}] - G_{t+1}N_{t+1} - C_t(\tilde{N} + N_{t+1}),$$

where N_t^g is the number of government officials, possibly zero, and G is government capital per worker. We interpret the government capital broadly to include both physical capital formed by government infrastructure investments and human capital formed by public education investments Note that, as with private capital, we assume that government capital has a depreciation rate of one, so that government investment in period t equals the stock of government capital per worker in period $t + 1$. This assumption is particularly convenient given our broad interpretation of public capital because, as in the case of human capital, it implies that new public investments must be made in each generation of workers. Note also that we are not considering government debt at this point, a topic that is discussed in a later section.

The benefit of government capital has not been identified as yet. The labor productivity index, D, is a function of the disembodied level of technology, E, and government capital per adult worker and is given by

$$D_t = E_t^{1-\mu} G_t^{\mu}, \tag{10a}$$

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where $0 < \mu < 1$ is a constant parameter. We assume that E progresses at the exogenous rate q. This specification of the impact of government capital is similar to those used by Aschauer (1989) and Clarida (1993). Similarly, TFP in the traditional sector is

$$A_t = (\varepsilon^g G_t)^{\mu} (\tilde{e}_t E_t)^{1-\mu}, \tag{10b}$$

where $\varepsilon^g \leq 1$, because public capital is assumed to be less useful to traditional production in general [as in Loayza (1996)], and where $\tilde{e}_t$ is the *relative* state of technology in traditional production. We leave the behavior of $\tilde{e}_t$ unrestricted for the moment, but we will eventually view it as declining with development (i.e., the pace of technological change is more rapid in the modern sector than in the traditional sector).

To solve the government's problem, we first rewrite the government budget constraint to incorporate the private sector equilibrium. The government accounts for the general equilibrium interactions of the private sector when setting its policies. This means that the government accounts not only for the household responses given by (5) and (6), but also for the equilibrium response given by (7) and (9). Substituting the various features of the private sector equilibrium into the budget constraint and rearranging allows us to rewrite the government budget constraint as

$$C_t = \frac{E_t}{(1+\tilde{m}_t)} \left\{ \frac{l_t^{\sigma} w_t \sigma_t}{1-\alpha} - (1+q)(1+n) g_{t+1} - m_t^g c_t^g \right\},$$

where $m_t^g \equiv N_t^g / N_t$, $l_t^{\sigma} \equiv l_t + \frac{\varepsilon(1-\sigma_t)}{1-\varepsilon\sigma_t}(1-l_t)$ is the effective labor input for the government's tax base, $g_t = G_t/E_t$ and $c_t = C_t/E_t$ are the detrended values for the government capital stock and government services provided per worker, and

$$w_t \equiv \frac{W_t}{E_t} = (1-\alpha)\, g_t^{\mu} \left[\frac{(1-\sigma_t)\,\alpha}{1+r} \right]^{\alpha/1-\alpha}$$

is the detrended formal sector wage. For simplicity, in the case where government policy is set by distinct government officials, we assume that the number of government officials rises at the same rate as the population of workers, so that m_t^g is constant throughout. Note that a sufficient condition for the government's problem to be well defined is $\beta(1+q) < 1$.[6]

After the expression for C_t is substituted into the government's objective function, the problem for the government is to choose sequences for c^g, σ, and g to maximize utility over an infinite horizon. The associated first-order conditions are

$$\frac{\phi^g}{c_t^g} \equiv \frac{(\phi + \tilde{\phi})\gamma m^g}{c_t} \tag{11a}$$

$$\frac{\beta\mu}{g_{t+1}} \left\{ \frac{\gamma}{1-\alpha} \frac{\sigma_{t+1} l_{t+1}^{\sigma} w_{t+1}}{c_{t+1}} + (1+\beta) \right\} = \gamma \frac{(1+q)(1+n)}{c_t} \tag{11b}$$

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$$\frac{(\phi+\tilde{\phi})\gamma w_t l_t^{\sigma}}{c_t(1-\alpha)}\left\{1+\frac{\partial l_t^{\sigma}}{\partial \sigma_t}\frac{\sigma_t}{l_t^{\sigma}}-\frac{\alpha}{1-\alpha}\frac{\sigma_t}{1-\sigma_t}\right\}$$
$$=(1+\beta)\left\{\frac{\phi+\tilde{\phi}}{(1-\sigma_t)(1-\alpha)}+\frac{\tilde{\phi}}{\alpha}\left[\frac{\varepsilon}{1-\varepsilon\sigma_t}-\frac{1}{(1-\sigma_t)(1-\alpha)}\right]\right\}. \quad \textbf{(11c)}$$

Equation (11a) is the first-order condition for consumption by government officials. The marginal benefit, the left-hand side, is the increase in utility of government officials from the rise in their consumption. The marginal cost, the right-hand side, is the fall in utility of private sector households from the reduced consumption of government services.

Equation (11b) is the first-order condition for the choice of g_{t+1}. The marginal benefit is made up of two parts. The first part gives the rise in the next period's tax base from greater government investment in the current period. The second part is the rise in welfare of the next generation of both private households due to the rise in labor productivity associated with the increase in government capital. The marginal cost, the right-hand side, gives the loss in current period private government services caused by using more current tax revenue for investment.

Equation (11c) is the first-order condition for the choice of σ_t. The marginal benefit is the rise in government services financed by the increased tax revenue. The direct benefit of a higher tax rate is mediated by a reduction in the tax base, as workers reduce their labor supply to the modern sector when it is taxed more heavily than the traditional sector ($\partial l_t/\partial \sigma_t \leq 0$) and as private physical capital intensity falls with taxation ($-\frac{\alpha}{1-\alpha}\frac{\sigma_t}{1-\sigma_t}$). The right-hand side gives the marginal cost of taxation. The first term on the right-hand side captures the lost in welfare from reducing the after-tax wages of workers. The more complicated second expression on the right-hand side captures the effect of taxation on traditional producers. If the traditional sector is taxed as heavily as the modern sector ($\varepsilon = 1$), then this expression vanishes, because labor costs in the traditional sector will not be lowered by a rise in taxes. However, if taxes chase workers into the traditional sector because they are less heavily taxed there ($\varepsilon < 1$), then traditional wages will fall and the traditional producer is made better off—lowering the private marginal cost of labor taxes.

4. EXPLAINING FISCAL POLICY

The Introduction mentions three general facts about fiscal policy and development.

(F1) The size of government increases as an economy develops.
(F2) The rise in government and taxation is associated with rising or constant economic growth rates.
(F3) Today's developing countries have larger government sectors than did today's developed countries at similar stages of development.

This section uses the model of the previous section to offer possible explanations for each fact. The explanations are based, in part, on the following two

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propositions. The first proposition determines a closed-form transition equation for public capital accumulation. We simplify notation a bit by restricting parameter values to satisfy the condition $\phi^g + \gamma(\phi + \tilde{\phi}) = 1$; i.e., the weights placed on government consumption by public officials and private households sum to one.

PROPOSITION 2. *For any value of ε and any tax rate sequence, the transition equation for public capital accumulation is*

$$g_{t+1} = \frac{B}{(1+q)(1+n)}\sigma_t l_t^{\sigma}\left[\frac{(1-\sigma_t)\,\alpha}{1+r}\right]^{\alpha/1-\alpha} g_t^{\mu}, \tag{12}$$

where

$$B = \beta\mu\left[\frac{1+(1+\beta)(\phi+\tilde{\phi})}{1+\beta\mu(1+\beta)(\phi+\tilde{\phi})}\right] < 1.$$

Proposition 2 says that detrended government investment is simply a constant fraction of the tax base.

Given Proposition 2, we next characterize the optimal tax rate sequences in two extreme cases, where the traditional sector is fully taxed ($\varepsilon = 1$) and where the traditional sector is untaxed ($\varepsilon = 0$).

PROPOSITION 3.

(a) *For $\varepsilon = 1$, $\sigma_t = \sigma = \frac{1-\alpha}{1+(1-B)(1+\beta)\phi}$.*

(b) *For $\varepsilon = 0$, the optimal income tax sequence satisfies $1 > \sigma_t(\tilde{e}_t, \phi, \tilde{\phi}) > 0$, with*

$$\frac{\partial\sigma_t}{\partial\tilde{e}_t} < 0, \quad \frac{\partial\sigma_t}{\partial\phi} < 0, \quad \frac{\partial\sigma_t}{\partial\tilde{\phi}} > 0.$$

Assuming full ability to tax the traditional sector ($\varepsilon = 1$), as in part (a), implies that the optimal income tax rate is constant. This leads to the prediction that tax rates are constant over the course of development, a prediction clearly contradicted by the data. However, when the traditional sector cannot be taxed ($\varepsilon = 0$), as in part (b), then the optimal income tax changes over time. In particular, if the pace of technology in the modern sector exceeds that in the traditional sector, i.e., $\tilde{e}_t$ decreases over time, then the income tax rate rises over time.

We now relate the results from Propositions 2 and 3 to the three fiscal policy facts. The intuition for the result that $\partial\sigma_t/\partial\tilde{e}_t < 0$, from part (b), rests on the fact that taxation becomes less costly as the traditional sector shrinks. This offers a possible explanation for (F1). As shown in the Appendix, the amount by which the tax base falls, as tax rates rise, is increasing in the size of the traditional sector. The marginal cost of increasing the tax rate is high when the traditional sector is large, and declines over time as the traditional sector shrinks. Thus, during the structural transformation from traditional to modern production, the economy experiences rising tax rates. Combined with the fact that the share of labor in the modern sector rises, the relative size of government unambiguously increases.

The second development fact, (F2), states that even though the size of government and taxation are increasing, economic growth rates are increasing or at least

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constant. The presence of a traditional sector that is hard to tax is also important in explaining this fact. To see why, suppose that $\varepsilon = 1$ and the tax rate is fixed over time. In this case, the tax base grows solely due to growth in government investment. With public capital accumulation subject to diminishing returns ($\mu < 1$), output, the tax base, and government capital all grow at a decreasing rate [see (12)].

Consider the same economy with the exception that $\varepsilon = 0$, the traditional sector is untaxed. Now both the tax base and the tax rate grow over the course of development. This causes government investment, which is a constant fraction of the tax revenue, to grow as a fraction of total output and income. The increasing rate of government investment works against the diminishing returns to investment, and may result in a constant or even rising growth rate. We calibrate the model in Section 6 with a conservatively low estimate of μ, yet we find that the rise in the rate of government investment more than offsets diminishing returns, causing growth rates to gradually rise.

Thus, (F2) may also simply be a by-product of the economic transformation. The economic transformation increases the tax base, leading to a rise in tax rates. The rise in both the tax base and tax rates increases the rate of government investment over time, which helps to offset or mediate the diminishing returns associated with a growing stock of public capital.

The results from Proposition 2 offer two possible explanations for (F3)—the relatively high tax rates and government shares in today's developing countries. A third explanation for (F3) is discussed in the next section. First, governments that place less weight on the private sector's welfare will set higher tax rates. As noted by Glaeser et al. (2004), almost all developing countries after World War II were dictatorships. A lack of institutional constraint on executive power is likely to be correlated, although not perfectly so, with relatively low regard for private sector welfare. Acemoglu et al. (2005, 2006) provide evidence that Europe and its Western offshoots had institutions that placed constraints on executive power early on in their development, whereas currently developing countries do not. Thus, the relatively high tax rates of currently developing countries could stem from government with relatively few institutional constraints on its power—modeled here as relatively high values of ϕ^g and relatively low values of ϕ.

A low value for ϕ also implies a low value of B, i.e., a low investment share of the government budget. The economy then suffers not only from high tax rates, but also from low levels of investment. These consequences of a lack of institutional constraint on the executive may slow the structural transformation and economic growth and permanently lower the steady level of worker productivity.

A second way to generate a high-tax economy is to alter the *composition*, rather than the *level*, of the government's concern for the private sector. Formally, we can raise $\tilde{\phi}$ and lower ϕ, but keep the sum of ϕ and $\tilde{\phi}$ constant. Raising $\tilde{\phi}$ and lowering ϕ increases the government weight on traditional producers relative to workers. Traditional producers prefer high taxes because they lower wages and labor costs in the traditional sector. Thus, tax rates will be higher in the economy with relatively high $\tilde{\phi}$. To view this as a possible explanation of (F3), one needs to

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explain why today's developing countries would favor traditional producers more than today's developed economies did during their historical development.

In the vast majority of countries, the most important type of traditional production is in labor/land-intensive agricultural production. The concentration of rural land ownership, however, differs significantly across countries at similar stages of development. For example, the United States and Canada had relatively egalitarian distributions of land compared to countries in Latin America, where the ownership of land was concentrated among a small fraction of the rural population. When land ownership is concentrated in the hands of a few, one might expect that the wealthy landowners will have significant political influence that shifts the favor of government in their direction. Thus, high tax rates may appear in developing countries with concentrated landownership and political regimes that fail to limit the disproportionate influence of the wealthy. To the extent that this combination is commonplace among developing countries, we have offered a second explanation for (F3). The next section offers a third explanation.

5. GOVERNMENT DEBT

In this section we consider what happens when government debt is allowed. With government debt, private consumption of government services can be written as

$$C_t = \frac{E_t}{(1+\tilde{m}_t)}\left\{\frac{l_t^{\sigma} w_t \sigma_t}{1-\alpha} + (1+q)(1+n)b_{t+1} - (1+q)(1+n)g_{t+1} - m^g c_t^g - (1+r)b_t\right\},$$

where b_t is detrended government debt per worker. If the government is unrestricted in its choice of b_t, then along with (11) we get the additional first-order condition

$$\frac{c_{t+1}}{c_t} = \frac{\beta\,(1+r)}{(1+q)(1+n)}, \tag{13}$$

a standard Euler condition for the path of consumption. In a model where the developing economy has the same β, q, and n as the rest of the world, it is reasonable to insist that the world interest rate satisfy the condition $1 + r = (1+q)(1+n)/\beta$. However, the world interest rate conditions implies that private consumption of government services in *all* economies, developing economies included, is constant over time; that is, private consumption of government services is always at its steady state value.

This counterfactual prediction stems from the unrealistic assumption that the government of a developing country can borrow at the going interest rate with no restrictions from the developed world. A more reasonable assumption is that the government is allowed to borrow to finance government capital formation, but not consumption. Under this borrowing constraint, we have $b_{t+1} = g_{t+1}$. Substituting

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the constraint into the expression for government consumption above and solving the government problem generates the following proposition.

PROPOSITION 4. *For any value of ε and any tax rate sequence, public capital accumulation satisfies*

$$g_t = \hat{B}\frac{\sigma_t}{1+r}l_t^{\sigma}\left[\frac{(1-\sigma_t)\,\alpha}{1+r}\right]^{\alpha/1-\alpha} g_t^{\mu}, \tag{14}$$

where

$$B < \hat{B} = \mu\left[\frac{1+(1+\beta)(\phi+\tilde{\phi})}{1+\mu(1+\beta)(\phi+\tilde{\phi})}\right] < 1.$$

Furthermore, optimal taxes have the same form as in Proposition 3, except that B is replaced by $\hat{B}$, implying that the optimal tax is higher, other things constant, than in Proposition 3.

The proposition tells us that constrained borrowing does not affect the qualitative conclusions of the previous section. The analysis that was conducted in the previous section can be repeated and will go through without qualitative changes when borrowing is allowed.

However, quantitative outcomes are affected by borrowing. Tax rates are higher at any given value of l_t. Borrowing allows the payment of government investment to be postponed, which lowers the cost of public investment. This raises investment expenditures, including future interest payments, and the taxes needed to finance them. However, it is unclear whether detrended public capital (net of interest expenses) will be higher or lower, because one can show that $B/(1+q)(1+n) > \hat{B}/(1+r)$—the rate of public investment out of a given tax base is higher without borrowing. Finally, note that (14) is *not* a difference equation. For given tax rates and a given rate of investment out of tax revenues, borrowing allows the government to jump to its steady state (conditional on given tax rates) rather than transition toward it. This implies that under borrowing, investment responses will be more sensitive to changes in the tax base.

In summary, granting the government access to borrowing raises tax rates for a given level of development. *If* poor countries today are able to borrow more heavily than developing countries did historically, then government debt is a third possible explanation for (F3). However, this is not generally true. During the late nineteenth century and early twentieth century the Western offshoots (Australia, Canada, Argentina, United States, and New Zealand), as well as the developing economies of Sweden and Norway, borrowed heavily from Europe [Van den Berg (2004, p. 500)]. The access to funds for government, *in itself*, does not explain the difference in tax rates between today's and yesterday's developing economies.

6. CALIBRATION EXPERIMENTS

In this section we calibrate the model to gauge the quantitative importance of the link between the structural transformation and fiscal policy. The calibration is

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based on the historical patterns observed in Figures 1 and 2. We interpret a period of the model to be 30 years. The exogenous rate of technological change (q) is set to match, along with the endogenous contribution of government investment, the average annualized growth rate of labor productivity over the period 1870 to 1990, 2.27% for the 11 countries from Figure 2. The annualized population growth rate (n) was set to 1%. This is similar to the population growth rates at the end of the twentieth century. We do not attempt to account for the higher population growth rates observed at the beginning of the century. The annualized international after-tax rate of return to capital (r) is set to 7% percent, similar to estimates of the return to physical capital found in Caselli and Feyrer (2007). The parameter β is set equal to $(1+n)(1+q)/(1+r)$, so that the detrended growth of government consumption in the steady state is zero. The parameter α is set to its standard value of 1/3.

The output elasticity for public capital (μ) is set to 0.30. This is somewhat less than the value estimated by Aschauer (1989) and Clarida (1993). However, the value $(1-\alpha)\,\mu = 0.20$ is in the middle of the range surveyed by Glomm and Ravikumar (1997). Also remember that we have broadened the interpretation of government investment to include public school expenditures. From this perspective, μ is also the wage elasticity of public school expenditures. If one holds student s' time constant, then a wage elasticity of 0.30 is too high [Manuelli and Seshadri (2005) is the only study we know that estimates this high a wage elasticity]. However, much of the rise in public school spending over the course of development is associated with rising school enrollment and rising attendance during the school year. In this case, where student s' time and expenditures rise together, the estimated wage elasticity is much higher, typically 0.50 or greater [e.g., see Rangazas (2002) and Manuelli and Seshadri (2005)]. On the basis of this reasoning, we also consider a case with μ set to 0.40.

To make the initial calibration more parsimonious, we set ϕ^g to zero. In a subsequent calibration experiment we consider the effect of increasing ϕ^g. The parameters ϕ and $\tilde{\phi}$ were set to match the initial government purchase and government investment shares in 1870 of 0.045 and 0.025. The government purchase share is from Figure 1. The government investment share is the sum of the shares of public expenditures on education and public investment in physical capital for the same 11 countries as Figure 1 [Tanzi and Schuknecht (2000, Table II.5 and II. 13)]. The value of γ is set to maintain the restriction, $\phi^g + \gamma(\phi + \tilde{\phi}) = 1$.

Finally, an important feature of the model is the share of labor in the modern sector, l_t. For the calibration experiment we interpret the modern sector as nonagriculture and the traditional sector as agriculture. Maddison (1994) contains estimates of the share of labor in agriculture for the 8 of the 11 countries and Cipolla (1974) for 10 of the 11 countries from Figure 1. For 1900, the average is 44% from Maddison and 43% from Cipolla. Maddison also presents data for 1990, where the average for the eight countries is 5%. In the simulation we assume that the decline in the agricultural share is linear from 44% in 1900 to 5% in 1990.

Cipolla (1974) also has estimates for 6 of the countries around 1850, with an average agricultural share of 57%. The average share for these 6 countries was 42%

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TABLE 2. Calibrated parameters

	$l_{1870} = 0.45$	$l_{1870} = 0.50$
q (annualized)	0.019	0.019
n (annualized)	0.010	0.010
α	0.333	0.333
μ	0.300	0.300
ϕ^g	0.000	0.000
ϕ	5.510	5.950
$\tilde{\phi}$	0.176	0.184
γ	0.069	0.069
$\tilde{e}_{1870}$	0.308	0.302
$\tilde{e}_{1900}$	0.287	0.288
$\tilde{e}_{1930}$	0.252	0.250
$\tilde{e}_{1960}$	0.201	0.200
$\tilde{e}_{1990}$	0.112	0.109

in 1900 (very close to the average for the larger sample of 10 countries). On the basis of these data, we used 55% as an upper bound estimate of the agricultural share in 1870 and 50% as a lower bound estimate. We match the historical shares exactly by setting the relative TFP in agriculture, $\tilde{e}_t$, so that the model's predictions about the labor share match the data. Table 2 summarizes the parameter calibration.

6.1. Historical Growth of Currently Developed Countries

Using this calibration, we now need only set the initial government capital intensity. The initial government capital intensity was set so that the intensity in 1870 was the same as that in 1840; i.e., the economy was in a quasi-steady state at the beginning of the simulation. Setting government capital intensity below this value would increase the growth explained by the model, so our approach is conservative.

Figures 3–5 compare the model's predictions for the government purchase share, the government investment share, and the growth rate in labor productivity with the actual data. The lower the initial share of labor in the modern sector, the greater is the growth in the tax base and the greater is the rise in the government purchase and investments shares. Over the period from 1870 to 1990, the model explains between 50% and 75% of the historical rise in government purchase shares and between 60% and 85% of the historical rise in government investment shares. The model also predicts gradually increasing growth rates in worker productivity that match the actual growth rates closely until the final period, 1960 to 1990, where actual growth rates jump. The model does not capture the "catch-up" growth of France, Germany, the United Kingdom, and Japan after they recover from the destruction of World War II. However, the model predicts gradually increasing growth rates for more than a century. The model does not generate the typical diminishing growth rates of neoclassical models because the rise in the

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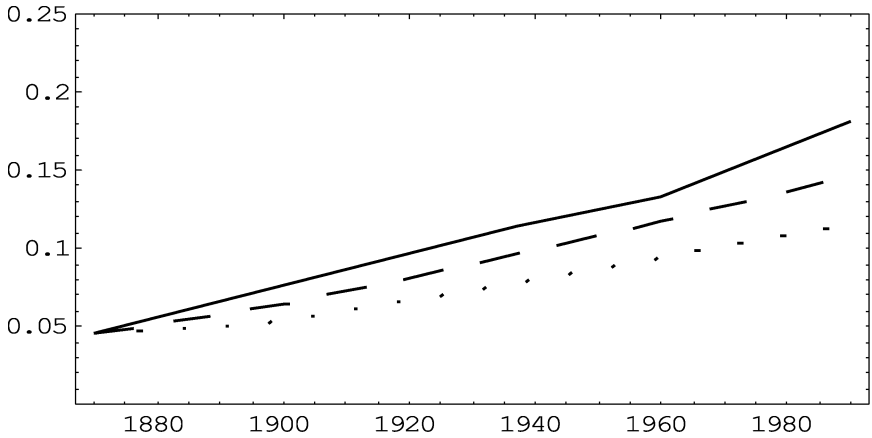


FIGURE 3. Predicted (dashed) versus actual (solid) government purchase share. *Note*: Long-dashed curve is for upper bound estimate of 1870 fraction in agriculture, and short-dashed curve is for lower bound estimate.

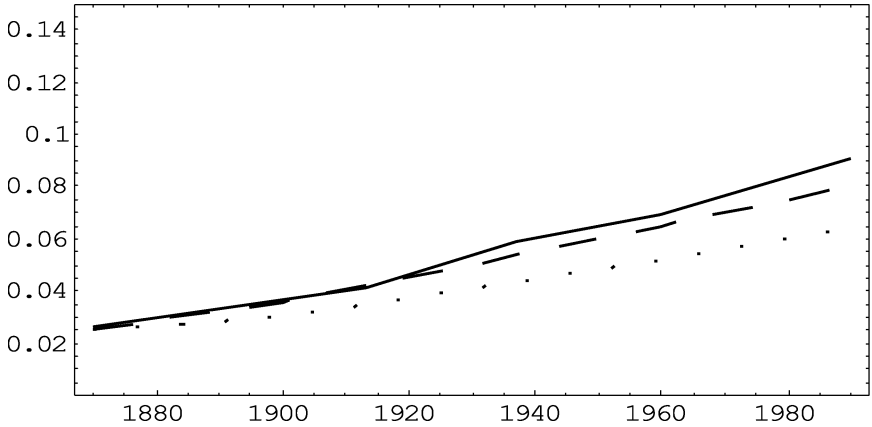


FIGURE 4. Predicted (dashed) versus actual (solid) government investment share. *Note*: Long-dashed curve is for upper bound estimate of 1870 fraction in agriculture, and short-dashed curve is for lower bound estimate. *Source*: Government investment share is the sum of the shares of public expenditures on education and public investment for the same 11 countries as in Figure 1 based on data from Tanzi and Schuknecht (2000, Tables II.5 and II.13).

government investment share out of GDP more than offsets diminishing returns to investment.

Given our calibration strategy, raising μ does not change the portion of the rise in government purchases and investment shares that is explained by the model; other parameter values change to maintain the shares in the initial period, and that is

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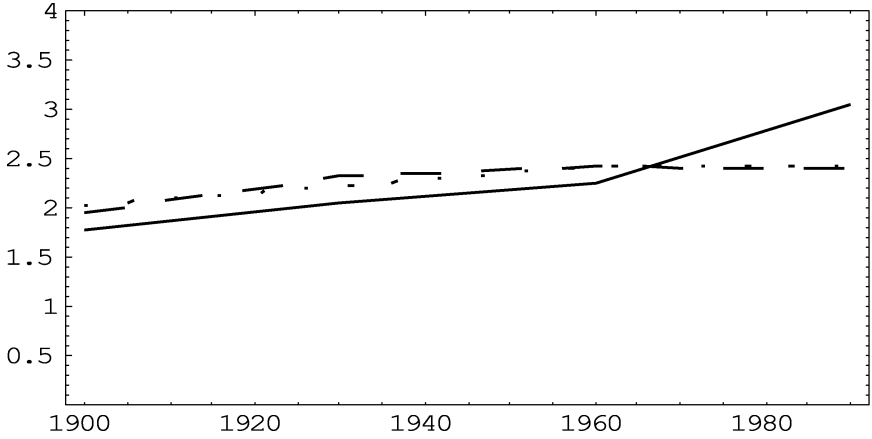


FIGURE 5. Predicted (dashed) versus actual (solid) labor productivity growth rates. *Note*: Long-dashed curve is for upper bound estimate of 1870 fraction in agriculture, and short-dashed curve is for lower bound estimate.

sufficient to maintain the paths in the government shares. Raising μ only changes the portion of the labor productivity growth that is explained by government investment rather than exogenous TFP. With μ set to 0.30, government investment explains between 1/4 and 1/3 of a percent of labor productivity growth per year from 1870 to 1990 (depending on the initial value of the share of labor in the modern sector). If μ is raised to 0.40, the annualized growth rate explained by government investment is between 0.40% and 0.50% per year.

6.2. Growth of Currently Developing Countries

At the end of the twentieth century, many developing countries had not yet reached the level of prosperity achieved by the currently developed countries in 1870. This is evidenced not only by low levels of worker productivity in currently developing countries, but also by the large shares of their workforces in traditional agriculture.

We use calibration experiments to examine two possible explanations for the large share of labor in traditional agriculture: (1) low TFP in the modern sector and (2) fiscal policy that is unfavorable to growth: high taxes and low government capital. We target the initial share of labor in agriculture at 75%, rather than the 50% to 55% targeted in the historical experiment above.

In the first experiment, we keep all parameters the same but raise the initial value of $\tilde{e}$ until the initial share of labor in agriculture is 75%. The rate of decline in $\tilde{e}$ is kept the same as in the historical experiment. In the second experiment, we change the weights the government places on its own welfare and the weights placed on working households and traditional producers. More specifically, we raise the weights on the welfare of the government officials and traditional producers and lower the weight on working households until taxes and government capital drive

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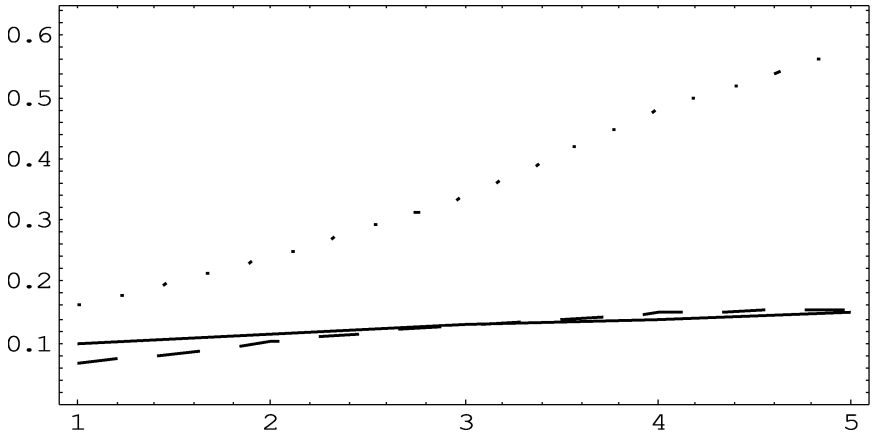


FIGURE 6. Tax rates. *Note*: Rich country (solid line), poor country due to low TFP (long-dashed curve), and poor country due to high taxes (short-dashed curve).

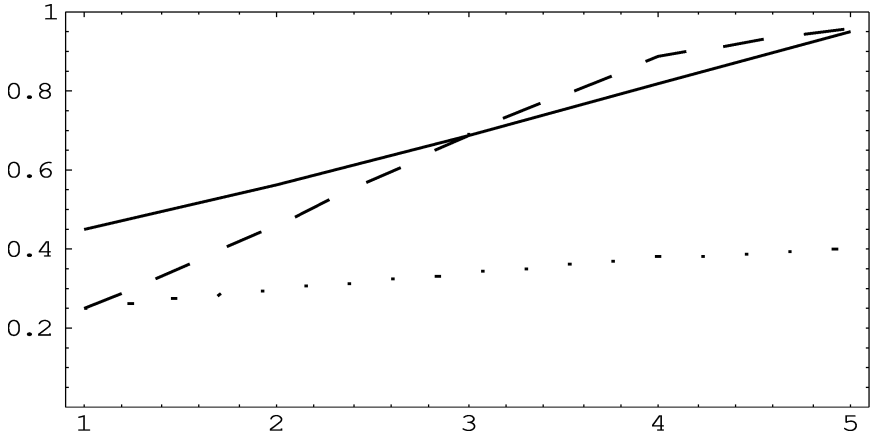


FIGURE 7. Share of labor force in modern sector. *Note*: Rich country (solid line), poor country due to low TFP (long-dashed curve), and poor country due to high taxes (short-dashed curve).

the share of labor in traditional agriculture to 75%. The path of $\tilde{e}$ is identical to that in the historical experiment.

We simulate the implied growth paths for the tax rates, the share of labor in the traditional sector, and the labor productivity growth rates for both the low-TFP and the high-tax developing countries. The results are given in Figures 6–8, where the paths are compared to the simulated paths for the currently developed countries from Figures 3–5.

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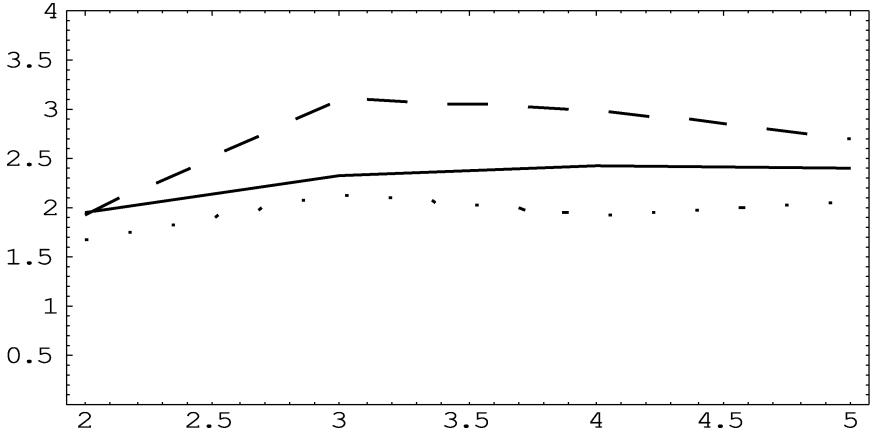


FIGURE 8. Labor productivity growth rates. *Note*: Rich country (solid line), poor country due to low TFP (long-dashed curve), and poor country due to high taxes (short-dashed curve).

Figure 6 indicates that tax rates in the low-TFP developing country begin below the 1870 tax rates of currently developed economies. After a few periods, the low-TFP country's tax rates converge to those found on the historical paths of the currently developed economies. The high-tax developing country starts with tax rates slightly above the 1990 tax rates of developed countries, and then tax rates rise dramatically over the course of development, reaching a rate in excess of 50% after five periods (120 years).

The consequence of the high-tax rates is made clear in Figure 7. The modern sector grows fast in the low-TFP country, quickly converging to the historical growth path of labor shares in the modern sector along the historical growth path of today's developed countries. However, the modern sector labor shares grow very slowly in the high-tax economy, remaining below 40% after five periods. There is two-way causation between the structural transformation and the size of government: exogenous factors that increase the pace of the structural transformation (e.g., technological progress) cause the relative size of government to increase, and exogenous factors that increase the size of government (selfish government officials or politically powerful landowners) slow the structural transformation.

Figure 8 shows that the growth rates of the two developing countries also differ dramatically. The initial labor productivity of the low-TFP economy is 2/3 of the labor productivity of the currently developed countries in 1870. The low-TFP country's transitional growth rates *exceed* the growth rates along the historical path of the currently developed countries. If we imagine the low-TFP country's initial period as 1870, then the labor productivity of this relatively poor country would converge toward the labor productivity of the currently developed economies. The opposite is true of the high-tax country. In its initial period, labor productivity

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is 57% of the historical labor productivity of the currently developed economies in 1870. The high-tax country's growth rates are *below* those of the currently developed countries. Beginning in the same period, the labor productivities of the high-tax countries and the currently developing countries would diverge over time.

7. CONCLUSIONS

The size of government expands as an economy develops over time. Our results suggest that this tendency is, in part, a natural consequence of structural transformation. During structural transformation, an economy shifts from traditional to modern production methods. We show that this causes the *marginal* cost of taxation to fall and tax rates to rise. This economic explanation for increasing government size complements explanations based on the spread of political voice as democracies develop and mature.

Rising tax revenues allow the government to increase the level of public investment over time. Increasing levels of investment help to offset the diminishing returns associated with public capital accumulation. Thus, as the public sector expands, the economy's growth rates do not necessarily decline.

We have argued that rising tax rates and government shares are a natural byproduct of the structural transformation associated with development. However, currently developing countries have high tax rates and government shares relative to their state of development. This may be a result of today's developing countries having relatively less democratic governments and institutions. In our model, relatively high tax rates, resulting from low concern for private sector welfare or disproportionate political influence of landed elites, reduce economic growth by slowing the structural transformation.

Our quantitative analysis suggests that the connections between the structural transformation and the size of government are potentially important. The model can explain 50%–75% of the rise in the government purchase share, and 60%–85% of the government investment share, in developed countries since 1870. The analysis also shows that high tax rates and government consumption at early stages of development can slow structural transformation and economic growth.

There are several ways to extend the study. First, we have focused on the size of government and the overall level of taxation. However, it is known that the *composition* of taxation changes with development. Sales taxes, property taxes, and capital income taxes are more prominent at early stages of development relative to labor income taxation [Burgess and Stern (1993) and Gordon and Li (2005)]. Second, we have not examined the possibility that the government can purposely target different amounts of public capital and consumption services to the modern and traditional sectors. Finally, we have kept population growth exogenous. There are important connections between the structural transformation and the demographic transition that could be examined, including the fact that fertility is higher in the traditional sector.

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NOTES

1. See Lindert (2004) for a historical analysis of the rise in social transfers.
2. This was true even in the United States well into the twentieth century [see, for example, Alston and Hatton (1991)].
3. Land is passed from one generation of landowners to the next either because of the absence of a land market in the early stages of development or because of a preference of landowners to keep the land in the family. Similar assumptions are common in the literature. See, for example, Drazen and Eckstein (1988), Doepke (2004), and Galor et al. (2006).
4. To simplify notation, we assume that government consumption services are consumed in the first period of life only.
5. For example, the same numbers of police officers and water facilities are provided per household in the traditional sector. However, the geographic dispersion of the households implies that delivering the government services is more difficult, resulting in less benefit.
6. The government objective function contains terms of the form $\beta^t \ln[(1+q)^t]$, which must converge to zero as t increases for the objective function to be well defined. Given that $(1+q)^t > \ln[(1+q)^t]$, we have $\beta^t \ln[(1+q)^t] < \beta^t(1+q)^t = [\beta(1+q)]^t$, which converges to zero if $\beta(1+q) < 1$.

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APPENDIX

A.1. PROOF OF PROPOSITION 1

Substitute the demand functions, given by (5) and (6), back into the utility functions for workers and landowners to form the indirect utility functions V_t and $\tilde{V}_t$. Substitute the indirect utility functions into (8) to rewrite (8) as

$$(1+\beta)\left\{\ln\left(\frac{\alpha}{1-\alpha}\right)+\gamma\ln\varepsilon^c+\ln(f_t)\right\}\geq 0.$$

Use (9) to eliminate f_t and solve (8) for the inequality condition in the proposition.

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A.2. PROOF OF PROPOSITION 2

Guess that the solution for the transition equation has the form indicated in the proposition, with B an undetermined coefficient that is independent of g_{t+i}. Substitute the guess into (11b) and use (11a) to verify that (11b) is satisfied for the value of B indicated in the proposition.

A.3. PROOF OF PROPOSITION 3

First, substitute (12) into (11c) to get

$$\frac{1}{1-B}\frac{1}{\sigma_t}\left\{1-\frac{\alpha}{1-\alpha}\frac{\sigma_t}{1-\sigma_t}+\frac{\partial l_t^\sigma}{\partial \sigma_t}\frac{\sigma_t}{l_t^\sigma}\right\}$$
$$=(1+\beta)\left\{\frac{\phi+\tilde{\phi}}{(1-\alpha)(1-\sigma_t)}-\frac{\tilde{\phi}}{\alpha}\left[\frac{1}{(1-\alpha)(1-\sigma_t)}-\frac{\varepsilon}{(1-\varepsilon\sigma_t)}\right]\right\}. \tag{A1}$$

Next, comparative statics reveals that

$$\frac{\partial l_t^\sigma}{\partial \sigma_t}\frac{1}{l_t^\sigma}=-\left(\frac{1-l_t^\sigma}{l_t^\sigma}\right)\left[\left(\frac{1-\varepsilon\sigma_t}{(1-\sigma_t)(1-\alpha)}-(1-\alpha)\varepsilon\right)\right]\frac{1}{\alpha}\frac{1-\varepsilon}{(1-\varepsilon\sigma_t)^2}, \tag{A2}$$

where

$$\begin{aligned} l_t^\sigma &= l_t+\frac{\varepsilon(1-\sigma_t)}{1-\varepsilon\sigma_t}(1-l_t)\\ &=1-\left[\frac{1-\varepsilon}{1-\varepsilon\sigma_t}\right]\tilde{\pi}_t f_t\\ &=1-\left[\frac{1-\varepsilon}{1-\varepsilon\sigma_t}\right]\tilde{\pi}_t\left[\frac{(\varepsilon^g)^\mu \tilde{e}_t^{1-\mu}(1-\varepsilon\sigma_t)}{\left[\frac{(1-\sigma_t)\alpha}{1+r}\right]^{\alpha/1-\alpha}(1-\sigma_t)}\right]^{1/\alpha}. \end{aligned} \tag{A3}$$

Setting $\varepsilon=1$ allows one to use (A1) to solve for the constant tax rate given in part (a) of the proposition. Setting $\varepsilon=0$ allows (A1) to be written as

$$\frac{1}{\sigma_t}=\left[\frac{1-l_t}{l_t}\frac{1}{\alpha}+\frac{\alpha}{1-\alpha}+\frac{(1+\beta)(1-B)}{1-\alpha}\left(\phi-\frac{1-\alpha}{\alpha}\tilde{\phi}\right)\right]\frac{1}{1-\sigma_t}. \tag{A1$'$}$$

The left-hand side is strictly decreasing in σ_t and can be interpreted as the marginal benefit of taxation. Using (A3), the right-hand side is strictly increasing in σ_t and can be interpreted as the full marginal cost of taxation, with the reduction in the tax base now included on the cost side. A sketch of the marginal benefit and marginal cost shows, for any $\tilde{e}_t \geq 0$ generating a positive marginal cost of taxation, that there is a unique interior optimal tax rate. Finally, the marginal cost of taxation is increasing in $\tilde{e}_t$ and ϕ and decreasing in $\tilde{\phi}$ for $1>\sigma_t>0$, completing the proof of part (b).

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A.4. PROOF OF PROPOSITION 4

Guess the solution for the transition equation has the form indicated in the proposition, with $\hat{B}$ an undetermined coefficient that is independent of g_{t+i}. Substitute the guess into the first-order condition for g_{t+i} and verify that the first-order condition is satisfied for the value of $\hat{B}$ indicated in the proposition. The form of the first-order conditions for tax rates is the same as in Proposition 3. The proof of Proposition 3 goes through with $\hat{B}$ substituted for B. That σ is higher than in Proposition 3 when $\varepsilon = 1$ is immediate. When $\varepsilon = 0$, the marginal cost of σ_t is shifted down when B is replaced with $\hat{B}$, which causes σ_t to be greater for any value of l_t.

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